

A Practical and Complete Implementation of SSUPRE without Static Single Use Representation

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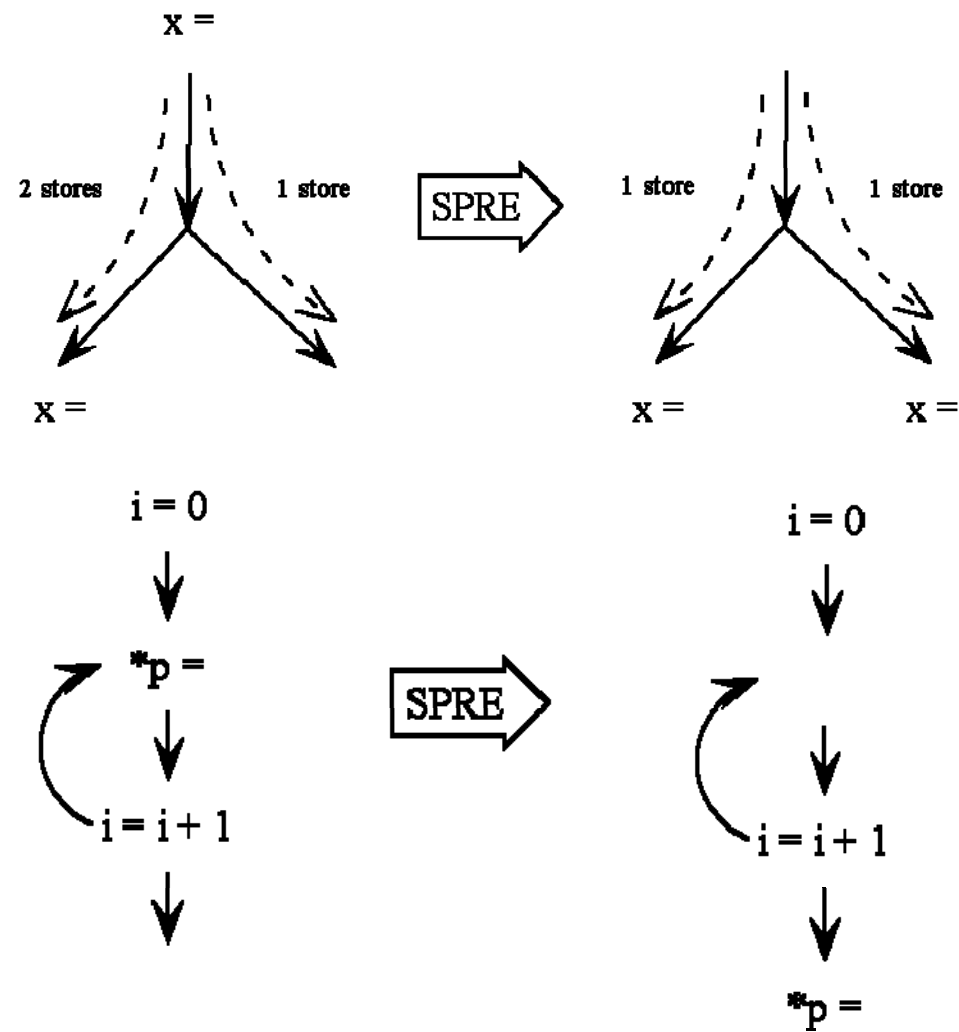


Outline

- Store partial redundancy elimination (SPRE)
- Related works: SSU representation
- Duality between SSAPRE and original SSUPRE
- New store PRE design and implementation
- Experiment

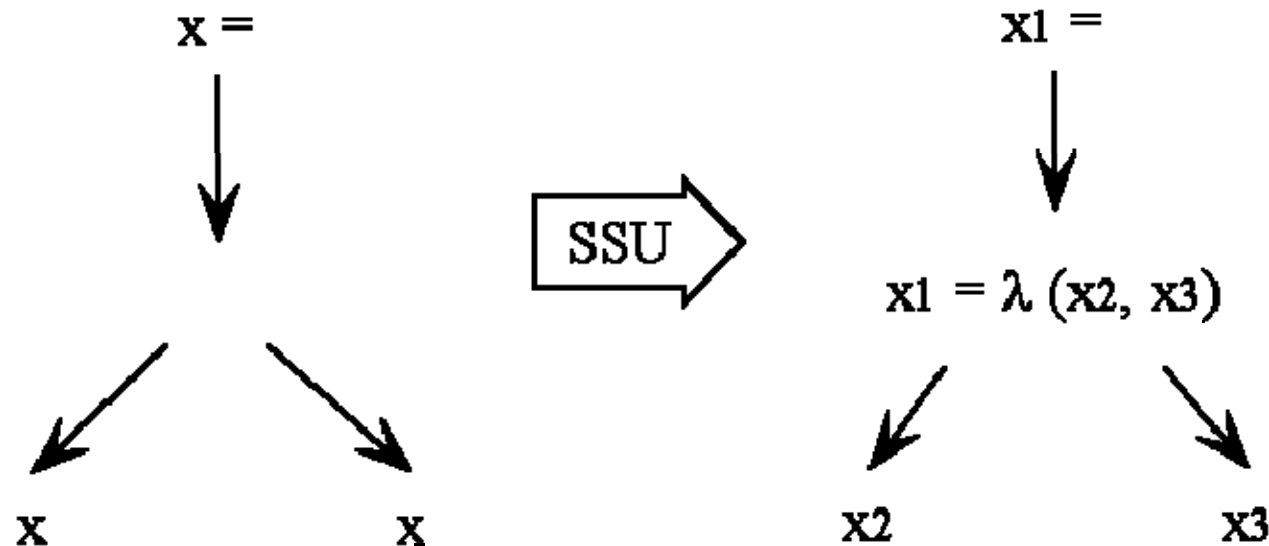
Store PRE

- SPRE, Store Partial Redundancy Elimination



Related Work: SSU representation

- Dual form to SSA form, one use—many def
- Dual symbol to $\varphi : \lambda$
 - merge more than one use at their PDF⁺
- SSI: Static Single Information = SSA+SSU



SSAPRE & SSUPRE

	SSAPRE (PLDI'97)	SSUPRE(PLDI'98)
Problem	Expression PRE	Store PRE
Input/Output	SSA	SSU
Redundancy	Available	Anticipated
Fully redundancy	Dominated	Post-dominated
Kills redundancy	Store (def)	Load (use)
Kills code motion	Store (alias load does not kill code motion)	Load & alias store
Movement	backward	forward

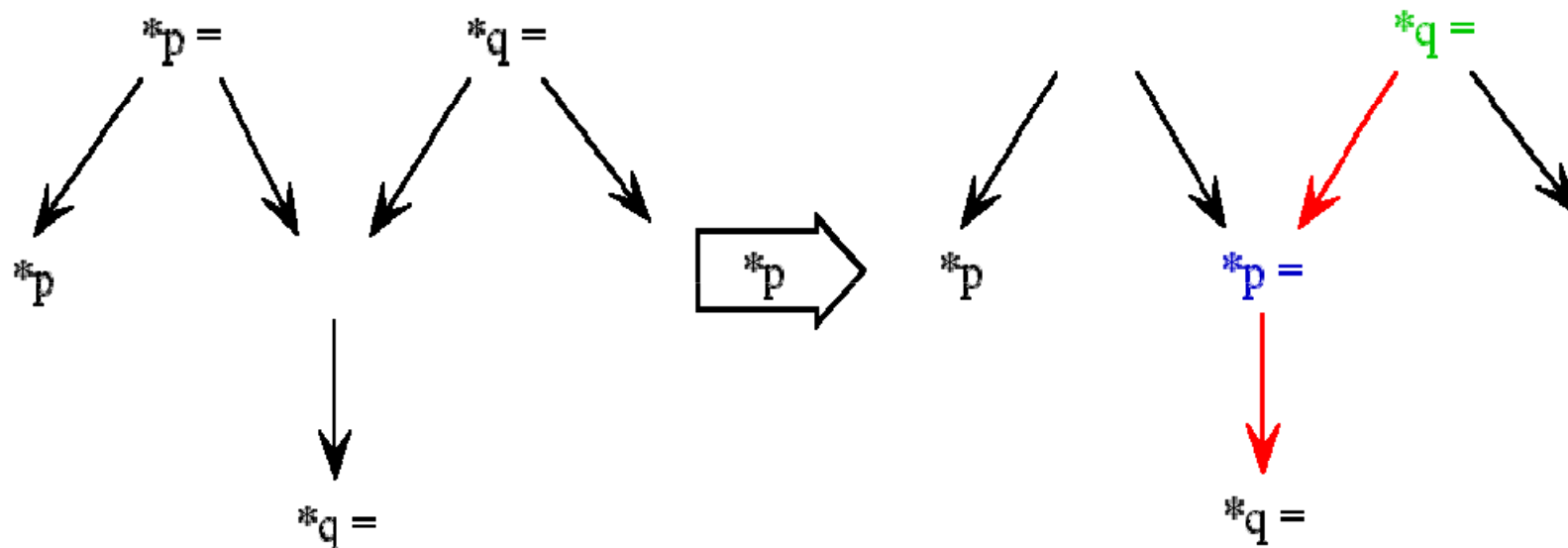
Duality between SSAPRE and SSUPRE

Disadvantages of original SSUPRE

- SSU is rarely used for other optimizations
 - SSA is a widely used representation
 - Construction cost : $SSU = SSA$
- Renaming step : alias load/store block code motion
 - Solution: traverse whole program for each worklist (store candidate) — too expensive!
 - Improvement: one-pass parallel renaming
 - just processes scalar stores
 - cannot process indirect stores

Disadvantages of original SSUPRE

- Suppose $*p$ is alias with $*q$
- After insertion for $*p=$, $*q$ is not redundancy
- Redundancy edge is broken
- Store candidates cannot alias with each other



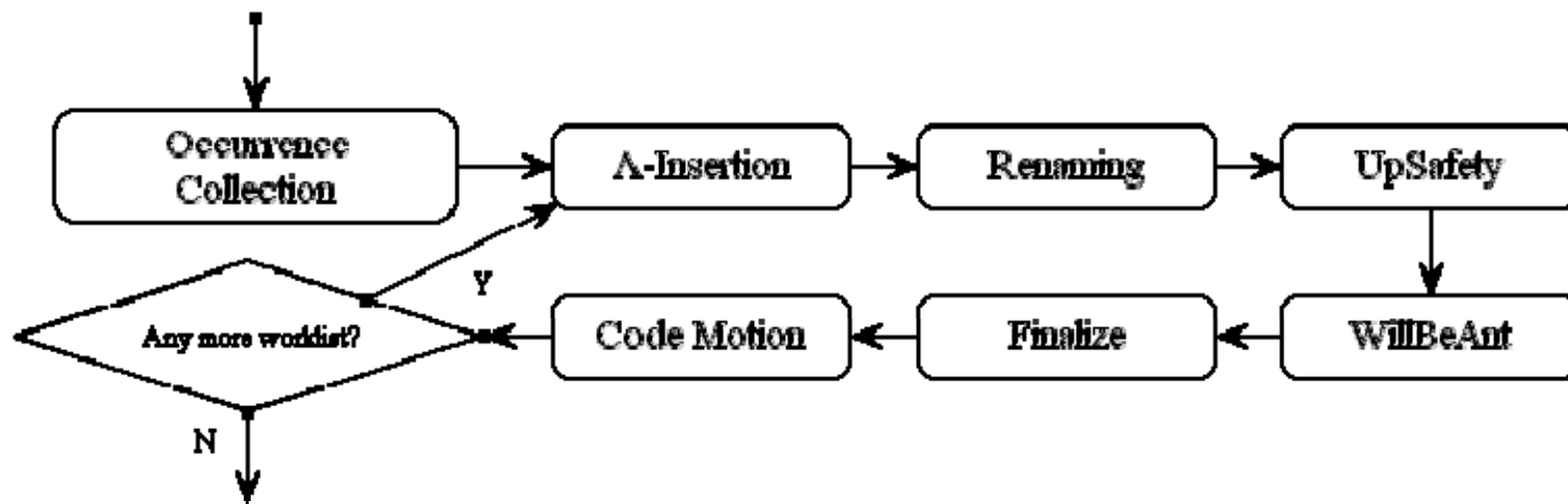
Disadvantages of original SSUPRE

Case	Type	Scalar store	Indirect store	Ratio (Indirect/Scalar)
164.gzip	C	3361	230	6.84%
175.vpr	C	9098	839	9.22%
197.parser	C	7246	714	9.85%
177.mesa	C	35939	7032	19.57%
183.equake	C	1478	127	8.59%
Geom.mean				10.09%
252.eon	C++	43941	23501	53.48%
483.xalancbmk	C++	444932	72227	16.23%
450.soplex	C++	39337	6293	16.00%
453.povray	C++	79404	14399	18.13%
Geom.mean				22.40%

Store numbers in some SPECCPU 2000 and SPECCPU 2006 cases

New SPRE

- Occurrence Collection
- Λ -Insertion
- Renaming



New SPRE – Occurrence Collection

- 6 kinds of occurrences
 - Real occurrences
 - Λ occurrences
 - Λ operand occurrences
 - Entry occurrence
 - Alias use occurrence
 - Alias definition occurrence
- Occurrences marked red are collected in this phase, others are collected in Λ -Insertion phase

New SPRE – Occurrence Collection

- Pre-order traverse for post-dominance tree
 - Bottom-up for each basic block and each statement
- Alias use occurrences and alias definition occurrences avoid multi-pass traverses
- After finishing a worklist
 - Add insertions – correctness
 - Remove deletions - performance
 - Into/from alias use/definition lists of unfinished worklist

New SPRE – Λ -Insertion

SSAPRE	SSUPRE	New SPRE
DF ⁺ of expressions	PDF ⁺ of stores	PDF ⁺ of stores
φ of variables	λ of variables	PDF ⁺ of loads

Occurrence	Insert Λ or not
PDF ⁺ of load	Insert
PDF ⁺ of alias load	Insert
PDF ⁺ of store	Insert
PDF ⁺ of alias store	Insert

Occurrence	Insert Λ or not
PDF ⁺ of load *p	Insert
PDF ⁺ of alias load of *p	Insert
PDF ⁺ of load p	Not insert
PDF ⁺ of alias load of p	Not insert
PDF ⁺ of store *p	Insert
PDF ⁺ of store p	Insert
PDF ⁺ of alias store of p	Insert
PDF ⁺ of alias store of *p	Insert

New SPRE - Renaming

- Pre-order traverse for post-dominance tree
- Maintain an occurrence stack, meet

Λ occurrence	Create a new version for the occurrence and push it into the stack.
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Real occurrence	If top of stack is a valid version, set the occurrence version same as top of stack. Otherwise, create a new version for the occurrence and push it into the stack.
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Λ operand occurrence	Occurrence version is same as top of stack.
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Entry occurrence	If top of stack is Λ occurrence, this Λ occurrence is not up-safe.
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Alias use occurrence	Push \perp into stack. If top of stack is Λ occurrence, this Λ occurrence is not up-safe.
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Alias definition occurrence	Push \perp into stack. If top of stack is Λ occurrence, this Λ occurrence is not up-safe.
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Experiment

Case	Type	Original SPRE	New SPRE	Ratio
164.gzip	C	0.029937	0.072098	2.408324147
175.vpr	C	0.063038	0.220402	3.496335544
197.parser	C	0.061984	0.194008	3.129969024
177.mesa	C	0.277901	1.21475	4.371160953
183.equake	C	0.015705	0.082862	5.276154091
252.eon	C++	2.0579	4.81357	2.339068954
483.xalancbmk	C++	5.27897	12.3048	2.330909249
450.soplex	C++	0.347467	0.994928	2.863374076
453.povray	C++	0.810145	5.36758	6.625455937
Geom. mean				3.413190368

Compile time for some SPECCPU 2000 and SPECCPU 2006 cases (seconds)

Thank You!